Mem. S.A.It. Suppl. Vol. 6, 137

Memorie della
Supplementi

High-Resolution Observations of 2/P Encke comet: preliminary results

L. Saba[1], M.T. Capria[2] and G. Cremonese[3]

[1] INAF-Osservatorio Astronomico di Torino
[2] INAF-IASF- Roma
[3] INAF-Osservatorio Astronomico di Padova e-mail: saba@to.astro.it

Abstract. We report the first results of an observational run carried out in November 2003 on the Comet 2P/Encke at TNG telescope, on La Palma, Canary Islands. We have performed high resolution spectroscopic observations of this comet, during its closest approach to the Earth, in the wide spectral range from 4700Å to 7920Å. It is the first time that a short period comet is observed with a high resolution spectrograph in such a wide spectral range. The preliminary results show few emission lines, confirming that in short period comets we may have low gas production and it is in agreement with previous observations of 2P/Encke pointing at a dark and dusty object.

Key words. Comets: spectroscopy

1. Introduction

Comet 2P/Encke is a member of the Jupiter family of short period ($P < 200$ yr) comets. It is the comet with the shortest known revolution period of only 3.3 years, allowing several observations. It is a faint and dusty object, with an albedo of 0.047 ± 0.023 (Jewitt, 2004) and its spectrum shows few but very interesting features (as C_2, CN, H_2O^+ and NH_2) (Goraya et al. 1986, Krishna Swamy 1997, Wyckoff 1983). Reach et al. (2000) computed the total mass loss, about $2 - 6 \times 10^{10}$kg per orbit. The comet is believed to be the parent body of the meteor shower of the Taurids.
During this close approach the nucleus of 2P/Encke was detected with the Arecibo S-band radar (Harmon & Nolan 2004): in the past only one radar detection has been carried out (Kamoun et al. 1982) on this object and it is the first comet detected at two different apparitions. Radar data, together with infrared observations (Fernàndez et al. 2000; Campins 1988) allowed to suggest a rotation period of 11 hours. Belton *et al.*(2000) suggested a short-axis-mode rotation with a period of 11.1 hours, and combining this result with the radar data, Harmon & Nolan (2004) suggests that the nucleus is an oblate object, with a long-axis dimension of 9.2 km. The estimated radar albedo of 0.05 is similar to that measured for C/IRAS-Araki-Alcock, suggesting that comet nuclei has surface densities in the range 0.5-1.0 g/cm^3. Despite the frequent opportunity to develop accurate spectroscopic observations, that allows to observe molecules and atoms present in the comet, till now an atlas of emission lines has not been compiled. The main aim of this work is to catalog all the

Send offprint requests to: Saba L.

Table 1. Orbital parameters

Date (UT)	HR:MN	α $(hh : mm : ss)$	δ $(deg : mm : ss)$	Δ UA	V_r km/s	T-mag	S-T-O (°)
2003-Nov-11	20 : 18	21 : 30 : 20.47	+38 : 03 : 52.7	0.269	−5.832	7.39	60.923

Table 2. Wavelenght observed

Order	Start (Å)	End (Å)	Order	Start (Å)	End (Å)	Order	Start (Å)	End (Å)
1	6224.72	6300.12	8	6702.88	6786.82	15	7265.40	7354.87
2	6285.65	6365.34	9	6777.85	6862.54	16	7353.56	7443.87
3	6351.55	6431.92	10	6854.52	6939.97	17	7443.88	7535.05
4	6418.84	6499.90	11	6932.94	7019.17	18	7536.45	7628.48
5	6487.57	6569.33	12	7013.17	7100.19	19	7631.35	7724.26
6	6557.79	6640.26	13	7100.19	7183.10	20	7728.68	7822.47
7	6629.54	6712.74	14	7179.34	7267.97	21	7828.52	7923.20

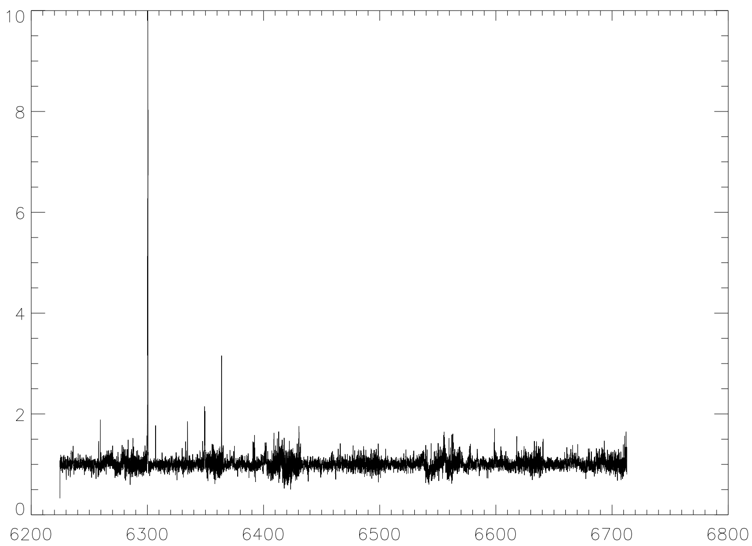

Fig. 1. The first seven order of the spectrum of comet 2P/Encke

emission lines visible in our data, then making a comparison with similar catalogues in literature. Since there are only catalogues of long period and new comets it will be very interesting to study the main differences. At the same time we may understand if some chemical processes occurr mainly in the coma of long period comets being more active.

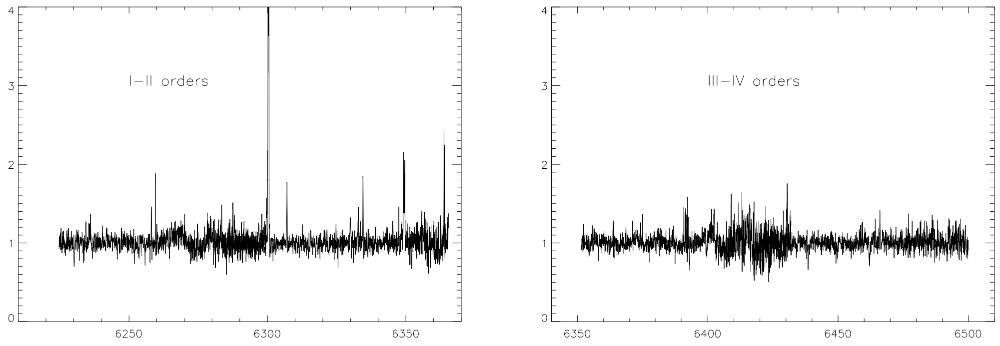

Fig. 2. The spectrum of 2P/Encke from 1 to 4 order

2. Observations and Data Reduction

During 2003, comet 2P/Encke had a close approach to the Earth allowing us to perform observations at low geocentric distance and to obtain information on the inner coma. Table 1 reports the orbital parameters of the comet during the observations.

The observation was made by using the SARG echelle spectrograph mounted at the 3.58 m TNG telescope, on La Palma, Canary Islands. The resolving power was 29000, and the slit was 1.6×8 arcsec. Further details on the instrument can be found on *http://www.pd.astro.it/sarg/*.

CCD spectra were processed with the ECHELLE package on IRAF. The data have been treated following a standard reduction procedure, as bias subtraction, flat-field correction, wavelength calibration and subtraction of the continuum due to the sunlight reflecting from the dust. Most of the cosmic ray features have been removed by hand. One frame is composed by the red chip covering the spectral range of 6200Å -7920Å and the blue chip covering 4750Å-6120Å. Up to now we have almost finished to reduce and to catalog the orders on the red chip.

3. Data analysis and preliminary results

The main goals of the study of spectra are to identify the species responsible for the observed lines and to obtain information about the physical condition present on the source. The purpose of this job is to compile a detailed atlas of emission lines for the Encke comet. To search them, every order is explored in detail. In Fig.1 is plotted the portion of spectrum till now explored, that is from 1^{th} to 7^{th} order, and in the following Figs. 2, 3, and 4 we show few details. In these orders we can see some emission lines and bands, as well as absorption bands owing to superposition of the telluric spectrum. In the spectral range analyzed the telluric spectrum is composed by the forbidden transitions of the red doublet of oxygen, at λ = 6300.30 and λ = 6363.78 (^1S-^3P), the emissions of OH and O_2, and by absorption bands of O_2 and H_2O. The telluric emission

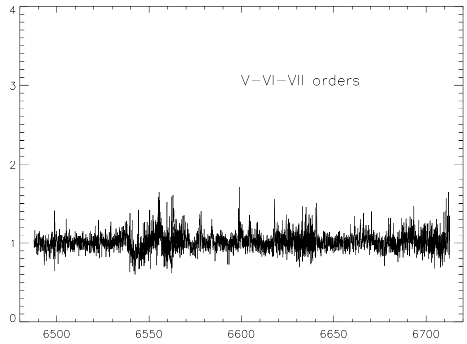

Fig. 3. The spectrum of 2P/Encke from 4 to 7 order

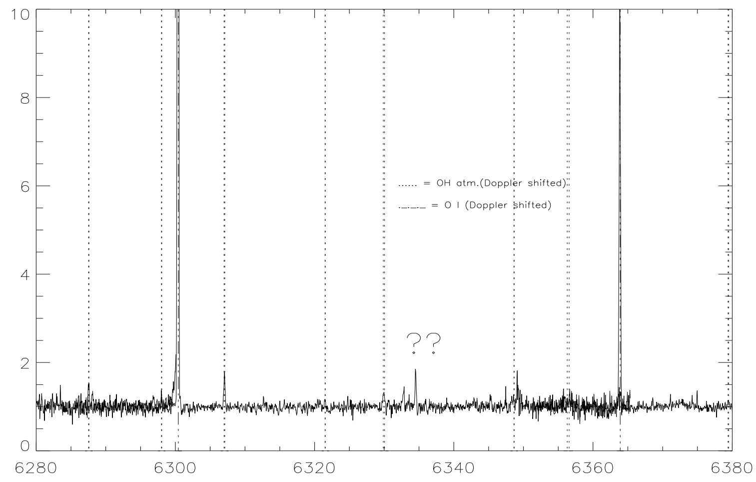

Fig. 4. Some Oh and O I lines

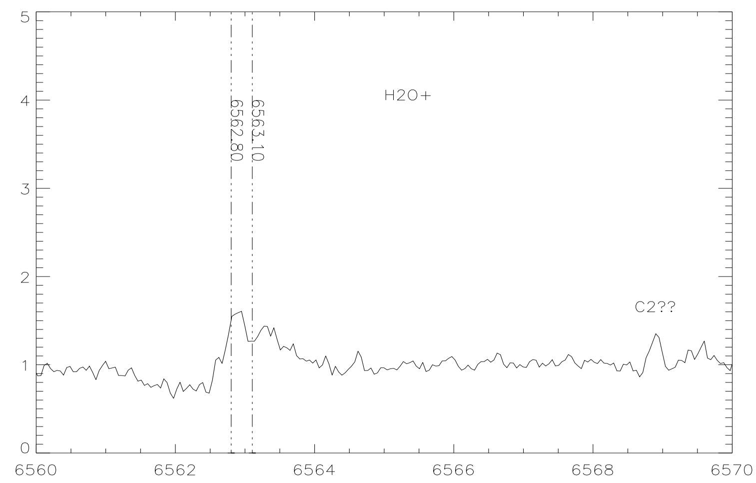

Fig. 5. Some $H_2 0^+$ and possible C_2 lines

lines are usually narrow and strong, respect to the cometary features. On the other hand, the absorption bands are broad and it is very difficult to remove them, because an high resolution spectrum of the sky is not available. In order to determine the exact position of the center of every line, the profiles are fitted through a composition of gaussian profiles, with the least squares algorithm, implemented in the IRAF package. The telluric lines can be identified by applying a Doppler shift, -$\Delta\lambda$, corresponding to the cometary velocity of -5.832 km/s. In this way, the rest frame of system comet-Earth is fixed onto the comet. Then the obtained positions will be compared with some catalogs of cometary's emission lines (Cochran et al.

2002., Brown et al. 1996) and with a catalog of telluric emission lines (Osterbrock et al. 1996). Fig.4 and Fig.5 show some interesting magnified portion of spectrum, and some lines are indicated.

4. Conclusions

At the moment there are only very few catalogs of emission lines for long period and new comets and the atlas of the emission lines of the comet Encke will contribute to increase our knowledge of the physical and chemical properties of this object. Furthermore it will be very interesting to make a comparison between comets of different type.
According to a preliminary analysis of our data we can say that 2P/Encke spectrum is poor of features; maybe due to its frequent approaches to the Sun the comet has lost part the volatile elements it appears an object dark, dusty and very little active. In the spectral range explored so far, we have seen some lines of C_2, NH_2, and H_2O^+.

References

Asher, D.J., & Steel, D.I., 1998, P&SS, Vol.46, pag.205

Brown, M.E.,*et al.*, 1996, AJ, Vol.112-3, pag.1997

Campins, H.,1988, Icarus, Vol.73, pag. 508

Capria, M. T.,*et al.*, 2002, ACM Conf., pag. 693

Cochran, A.L., & Cochran, W.D., 2002, Icarus, Vol.157, pag.297

Fernàndez, Y.R. *et al.*,2002, BAAS., Vol. 34, pag.887

Goraya, P.S. *et al.*,1986, Journ. Brit. Astron. Assoc., Vol. 96, pag.210

Jewitt, D.,2004, AJ, Vol.128, Issue 6, pag. 3061

Krishna Swamy, K.S., 1997, "Physics of Comet", 2^{nd} Edition, World Scientific, Singapore

Harmon, J. K., & Nolan, M. C. , 2004, AAS, DPS meeting #36, #21.03 . 52, 325

Kamoun, P.G., *et al.*, 1982, Science, Vol. 216, pag. 293

Kresàk, L., 1978, Bull.Astron.Inst.Czechoslov., Vol.29, pag. 129

Osterbrock, D.E., 1996, Publ.Astron.Soc.Pac., Vol.108, pag. 277

Picazzio, E., *et al.*, 2002 ACM Conf.,pag.713

Reach, W.T. *et al.*, 2000, Icarus, Vol.148, pag.80

Sekanina, Z., 1991, JRASC, Vol.85, pag.324

Wyckoff, S., in "Comets", 1983, pag. 3, The University of Arizona Press, Tucson, Arizona